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Differences in Visuospatial Cognition Performance and Regional Brain Activation Between 20s and 40s

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Abstract

This study investigated the effect of aging on visuospatial cognition performance and regional brain activation between 20s and 40s. Eight right-handed male college students in their twenties and six right-handed male adults in their forties who were graduated from college participated in the study. A visuospatial task was presented while brain images were acquired by a 3T functional Magnetic Resonance Imaging (fMRI) system. Accuracy rate of visuospatial tasks was calculated. Using the subtraction procedure, activated areas in the brain during visuospatial tasks were color-coded by t-score. The double subtraction method was used to analyze the effect of the aging between the two age groups (i.e., 20s vs. 40s). Compared to the 40s the 20s showed higher visuospatial performance. The cerebellum, occipital lobe, parietal lobe, and frontal lobe were almost similarly activated for two age groups. Increased brain activations, however, were observed in some regions in the parietal and superior frontal lobes at 20s compared to 40s. There was more activation observed in some regions in the middle frontal and right inferior frontal lobes at 40s compared to 20s. These results suggest that the lowering of visuospatial performance with aging between 20s and 40s was correlated to the decrease of activation area in the parietal lobe and the change of activation area in the frontal lobe.

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1. Introduction

Lots of studies such as change in cognitive ability, change in amount of brain activity, and change in activated region due to aging are being carried out using functional Magnetic Resonance Imaging (fMRI). It has been reported that with aging there is a decrease in nervous activation of visual region due to light stimulation (Chung, Lee, Tack, 2006). Especially the research about the brain area which is connected with verbal, memory, and information processing due to the aging is being carried out. During verbal tasks there was a significant difference in an amount of neural activation due to the aging and a significant difference in brain region and neural network (Huettel, Singerman, McCarthy, 2001; Johnson, Mitchell, Raye, et al. 2004). During memorizing tasks there were reports that the old used a different neural network compared with the young in order to compensate the decrease of cognitive ability due to the aging. There was a difference in an amount of neural activation between the old and the young based on the types of memory task. Johnson et al.(2004), Lee, (1982) reported that compared with the young, the ability of the elderly to acquire new information was reduced and related activation of dorsolateral prefrontal cortex was also reduced.

Lots of studies which investigate the effect of the aging upon not only the basic cognitive processing but also higher cognitive function have been carried out using fMRI. But there is a lack of study about the effect of the aging on the diverse cognitive ability such as visuospatial, learning, and reasoning. To examine the effect of the aging on cognitive processing closely, new studies based on not only the various kinds of cognitive tasks but also various kinds of difficulty levels and age groups are required. Therefore, this study tried to examine the effect of the aging on the visuospatial performance and its neural activity by fMRI while the age group of 20s and 40s is performing visuospatial tasks.

2. Methods

2.1. Subjects

Eight male college students in their twenties (22.7 ± 2.5 years old) and six male adults in their forties (44.8 ± 2.9 years old) who were graduated from college participated in the study. All subjects were right-handed as a result of revised Edinburgh test (Lee, Kim, 1985). The overall procedure was explained to all subjects. All subject signed participation consent forms. All examinations were performed under the regulations of our Institutional Review Committee.

2.2 Visuospatial cognition tasks

20 items were selected from Korean versions of an intelligence test, an aptitude test, and a general aptitude battery (GATB) (Stebbins, et al.2002). Selected items consisted of the type which selects the same shape corresponding to the given figure from four given examples, and the type which selects the development figure of the given diagram as shown in Fig. 1.

2.3 Experimental procedure

The experiment consisted of 4 blocks; each block had both control and visuospatial items (Fig. 1). The control and visuospatial tasks were presented using SuperLab 1.07 (Cedrus Co.). Items were projected onto a screen and subjects were instructed to provide the correct answers. In response to control tasks, subjects were instructed to press the button corresponding to the number (1, 2, 3, or 4) projected on the screen (20 items per block). The number was given randomly at 3 sec. In the visuospatial task, subjects were asked to press the button to indicate the item corresponding to the target figure (5 items per block). Each item was given randomly at 12 sec.

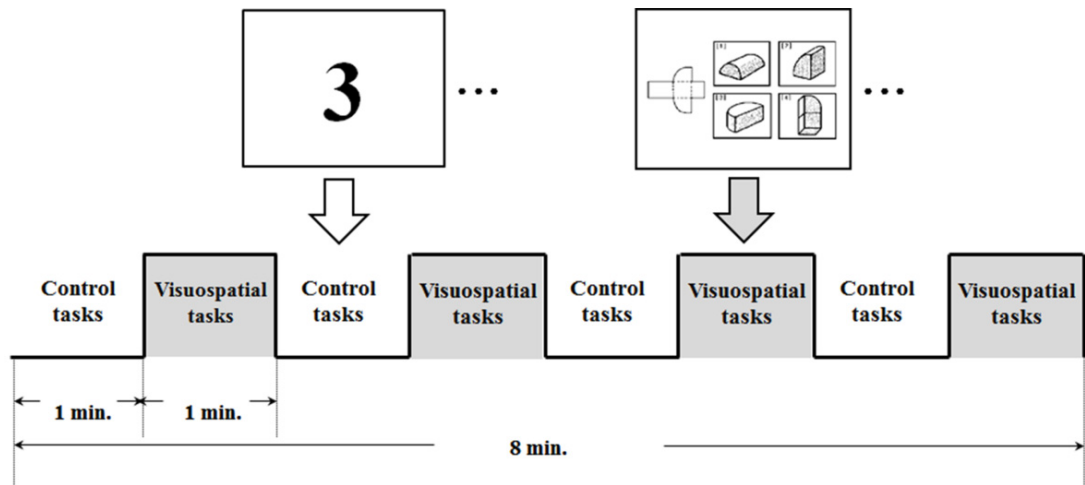


Figure 1. Experimental procedure

2.4. fMRI acquisition

Imaging was conducted on a 3.0T ISOL Technology FORTE (ISOL Technology, Korea) equipped with whole-body gradients and a quadrature head coil. Single-shot echoplanar fMRI scans were acquired in 35 continuous slices, parallel to the anterior commissure-posterior commissure line. The parameters for fMRI include the following: the repetition time/echo time [TR/TE] were 3000/35 ms, respectively, flip angle 60, field of view 240 mm, matrix 64×64 , slice thickness 4 mm, and in-plane resolution 3.75mm. Five dummy scans from the beginning of each run were excluded to decrease the effect of non-steady state longitudinal magnetization. T1-weighted anatomic images were obtained with a 3-D FLAIR sequence (TR/TE = 280/14 ms, flip angle = 60, FOV = 240 mm, matrix = 256×256 , slice thickness = 4 mm).

2.5. Data analysis

Accuracy rate (the number of correct answer / total number of item $\times 100$) was calculated. Independent t-test in SPSS (ver. 10.0) was used to investigate any significant difference in the accuracy rate between 20s and 40s. The fMRI data were analyzed with SPM 8 (Wellcome Department of Cognitive Neurology, London, UK). All functional images were aligned with the anatomic images of the study by using affine transformation routines built into SPM 8. The realigned scans were co-registered to the participant's anatomic images obtained within each session and normalized to SPM8's template image that uses the space defined by the Montreal Neurologic Institute, which is very similar to Talairach and Tournoux's (1988) stereotaxic atlas. Motion correction was done using a Sinc interpolation. Time-series data were filtered with a 240-s high-pass filter to remove artifacts due to cardiorespiratory and other cyclical influences. The functional map was smoothened with a 7-mm isotropic Gaussian kernel prior to statistical analysis. Statistical analysis was done both individually and as a group using a general linear model and the theory of Gaussian random fields implemented in SPM 8. Using the subtraction procedure, activated areas in the brain during visuospatial tasks were color-coded by T-score. Finally, the double subtraction method was used to analyze the effect of the aging between the two age groups (i.e., 20s vs. 40s).

3. Results

The mean accuracy rate was 64.5 ± 8.4 , and 51.3 ± 9.5 for 20s and 40s, respectively. There was a significant difference between the two age groups ($p=0.011$).

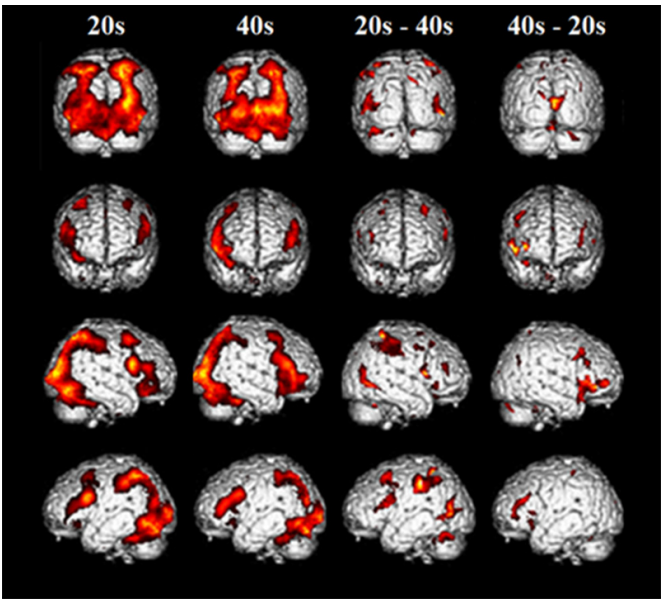


Figure 2. The brain activation areas of 20s and 40s during visuospatial tasks and contrasted brain activation areas (corrected $p<0.05$).

Table 1. Talairach coordinates, the Brodmann’s area, t-scores, and significant cluster size in the activated areas using the double subtraction method (corrected $p<0.05$).

Region		Brodmann area	Talairach coordinates			Cluster size	T-score
			x	y	z		
20s-40s	Right Frontal Lobe Sub-Gyral		40	12	20	92	28.28
	Right Superior Frontal Gyrus		26	14	48	119	19.59
	Right Inferior Frontal Gyrus	44	50	14	14	75	25.18
		9	60	16	26		14.13
	Left Frontal Lobe Sub-Gyral		-40	16	20	133	23.34
	Left Superior Frontal Gyrus		-26	10	48	110	24.25
	Left Inferior Frontal Gyrus		-56	14	26	86	21.08
	Right Superior Parietal Lobule		34	-46	62	146	26.79
	Right Inferior Parietal Lobule	40	50	-32	54	180	21.19
			44	-42	48		17.94
	Left Superior Parietal Lobule		-34	-46	60	113	26.82
	Left Inferior Parietal Lobule		-50	-34	46	163	28.15
40s-20s			-40	-50	48		25.45
	Right Middle Frontal Gyrus		48	38	-4	102	17.47
			36	52	-2		16.39
			24	-4	50		11.63
			50	26	28		11.58
	Right Inferior Frontal Gyrus	45	58	22	4	169	17.44
		45	56	30	2		16.3

	9	40	4	28		11.26
Left Middle Frontal Gyrus		-40	42	10	76	14.87
		-38	28	22		11.78
Right Occipital Lobe Cuneus		6	-92	10	193	13.56

Fig. 2 shows significantly activated brain areas during the visuospatial tasks for the two age groups. The cerebellum, occipital, parietal, and frontal lobes were almost similarly activated. Fig. 2 also shows the contrasting effects between 20s and 40s using the double subtraction method. There were more activation observed in some regions in the bilateral superior parietal lobes, bilateral inferior parietal lobes, bilateral superior frontal gyri, and bilateral inferior frontal gyri at 20s compared to 40s. There were more activation observed in some regions in the bilateral middle frontal gyri, right inferior frontal gyrus, and occipital lobe at 40s compared to 20s. The Talairach coordinates, the corresponding Brodmann area, t-scores, and significant cluster size of each activated area are shown in Table 1.

4. Discussion

Compared to the twenties the forties showed lower visuospatial performance. This result is similar to those of published papers which showed that with aging cognitive ability such as memory, verbal, and information processing decrease significantly (Chung, et al. 2006; Lee, 1982).

It is well known that during visuospatial tasks there are activities at the cerebellum and occipital, parietal, and frontal lobes and especially parietal lobe has an important role. In this study, regardless of age the activated region of brain during visuospatial tasks is similar to the published data. But there were some differences in neural activation of two age groups. Compared to the twenties reduced activation of parietal lobe of the forties was clear. This means that reduced visuospatial cognitive performance due to the aging between 20s and 40s is related with reduced activation of parietal lobe which is the core region of visuospatial cognition.

In relation to cognitive processing, as age increases the activation of frontal lobe generally decreases, but for some cases more activation could be selectively happened. This study showed that as compared to the forties the activation of superior frontal lobe of the twenties increased, the activation of middle frontal and right inferior frontal lobes of the forties increased. This result is similar to the published report such that to compensate the reduced cognitive ability, compared to the young the elderly used other neural network of the brain Lee, (1982).

It could be concluded that during visuospatial cognitive tasks as age increased, the activation of parietal lobe was clearly reduced and there was a change in the activation area in the frontal lobe.

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